

FOUR NEW *STREPTOCEPHALUS*
(CRUSTACEA, BRANCHIOPODA, ANOSTRACA)
SPECIES FROM SOUTH-EASTERN AFRICA

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(With 8 figures)

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ABSTRACT

Four new *Streptocephalus* species (*S. bidentatus*, *S. dendrophorus*, *S. spinicaudatus* and *S. bourquinii*) are presented. The morphology of the male antennae, frontal appendage and cercopods is used to separate species and this, together with the external egg morphology, is described and illustrated. All four species appear to be restricted to the eastern region of southern Africa. Three resemble known species from South Africa and can be allocated to groups that include species with similar antennal and frontal appendage morphology. The fourth species has male antennal morphology similar to the New World *S. similis*, but also shares some characters with a southern African species group.

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INTRODUCTION

The streptocephalids are a monogeneric anostracan family characterized by the male second antenna being a two-jointed structure with an enlarged median process terminating in a cheliform 'hand'. The genus includes about 50 species recorded from temporary freshwater pools in Eurasia, Africa and North America (Brtek 1974). A review of the southern African Branchiopoda by Barnard (1929) included 13 species of *Streptocephalus*. Subsequent to this, the African members of the genus were largely neglected. As part of an ongoing project on the Anostraca, 17 streptocephalid species from southern Africa were reviewed and divided into nine species groups comprising species that share male antennal and frontal appendage characteristics. During the examination of museum and other material collected in Zululand, the Kruger National

Park, Transkei and Swaziland, specimens were found that closely resemble known species but in which a few important characters showed constant differences from the original descriptions. These specimens represent new species and they are described below. The four new species occur allopatrically from the species to which they are closely related. *Streptocephalus bidentatus*, *S. spinicaudatus*, *S. dendrophorus* and *S. bourquinii*, described here, are each allocated to a species group.

MATERIALS AND METHODS

Anostracans were collected in north-eastern Natal and the Kruger National Park using a hand-held dip net, the size and mesh of which depended on water depth, pool size and the density of pool vegetation. Specimens were preserved in 70 per cent ethanol. Drawings were done using a Wild M-5 dissecting microscope and drawing tube. Dissected antennae were washed in distilled water, fixed in a 2 per cent osmium tetroxide and phosphate buffer solution for one hour before being dehydrated in a graded ethanol series. Specimens were then critical point dried, mounted on stubbs and coated with 20 nm of gold for scanning electron microscopical observation in a Hitachi S-570 microscope at accelerating voltage of 10 kV. Eggs taken from the brood pouch of preserved females were rinsed in distilled water, dried at 60°C for 24 hours before being mounted on stubbs, coated and observed as for the antennae.

The terminology used for the different male antennal parts follows Brendonck (1990) and that used to describe the frontal process of *S. dendrophorus* is from Belk & Pereira (1982). The terminology used to describe egg morphology is from Brendonck (1992).

Measurements were made using a graticule and are presented as total body length (mean $\pm$ standard deviation, or simply the mean and range if $n < 10$) from the front of the head (excluding antennae) to the tip of the cercopods. Antennal length was measured by totalling the length of the median antennal process from the head to the base of the hand, and the length from the base of the hand, in a direct line, to the apex of the thumb.

The material will be deposited at the South African Museum (catalogue numbers SAM-A40820 to SAM-A40833).

TAXONOMIC DESCRIPTIONS

Family **Streptocephalidae** Daday, 1910

Streptocephalus bidentatus sp. nov.

Figs 1A-C, 2A-C

Type material

Holotype. SAM-A40820, adult male (14,2 mm); collected 5 November 1990, by M. Hamer in a large (approx. 20 $\times$ 15 m) temporary pool south of Skukuza, Kruger National Park (25°03'S 31°38'E).

Paratypes. SAM-A40821, remainder of material from same locality, 28 males (14,7 $\pm$ 4,2 mm), 26 females (14,8 $\pm$ 7,5 mm).

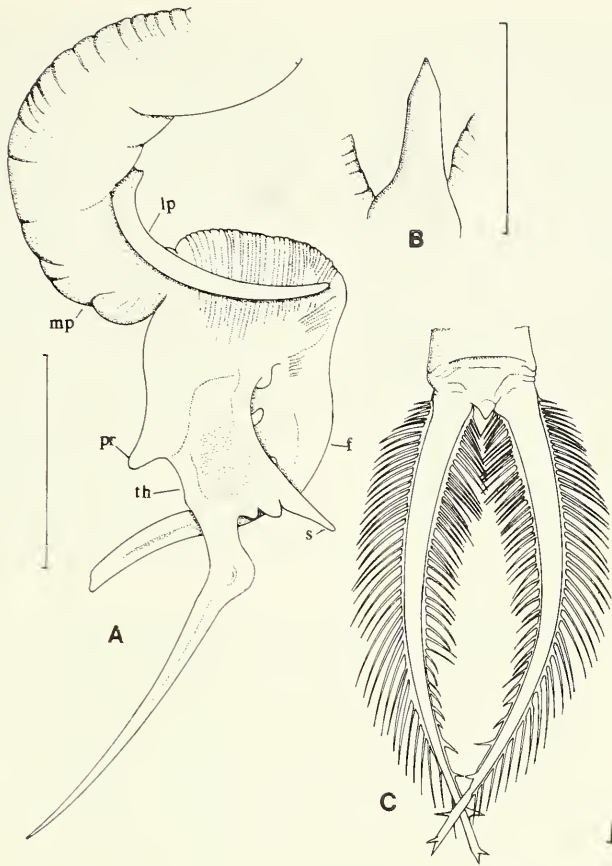


Fig. 1. *Streptocephalus bidentatus* sp. nov. A. Lateral view of left antenna of male. B. Dorsal view of frontal appendage. C. Dorsal view of male cercopods. Bar scales = 1 mm. Abbreviations: f = finger, lp = lateral process, mp = median antennal process, pr = projection, s = spur, th = thumb.

Other material

SAM-40822, 1 male (12,2 mm); collected from a pool in Swaziland, Hlane Game Reserve, 3 km from northern boundary (26°20'S 31°E) by T. Konstant. SAM-A40823, 18 males ($9,3 \pm 4,2$ mm), 15 females ($9,2 \pm 5,3$ mm); collected in the Kruger National Park, pools near Nhlangueni (24°42'S 31°38'E), by M. Hamer, October 1990. SAM-A40824, 21 males ($12,7 \pm 1,0$ mm), 9 females (12,9 mm, range: 9,8–14,0 mm); collected in the Kruger National Park, along Pumbe–Mozambique fence (24°14'S 31°57'E), by M. Hamer, 26 October 1990. SAM-A40825, 13 males ($12,3 \pm 7,0$ mm); collected in the Kruger National Park, 3 km north of Nkokodzi (23°17'S 31°20'E), by M. Hamer, October 1990. SAM-A40826, 47 males ($13,6 \pm 11,8$ mm), 9 females (14,3 mm, range = 12,0–14,9 mm); collected from a temporary pool on the Makatini Flats (27°24'S 32°10'E), north-eastern Natal by M. Hamer in October 1987.

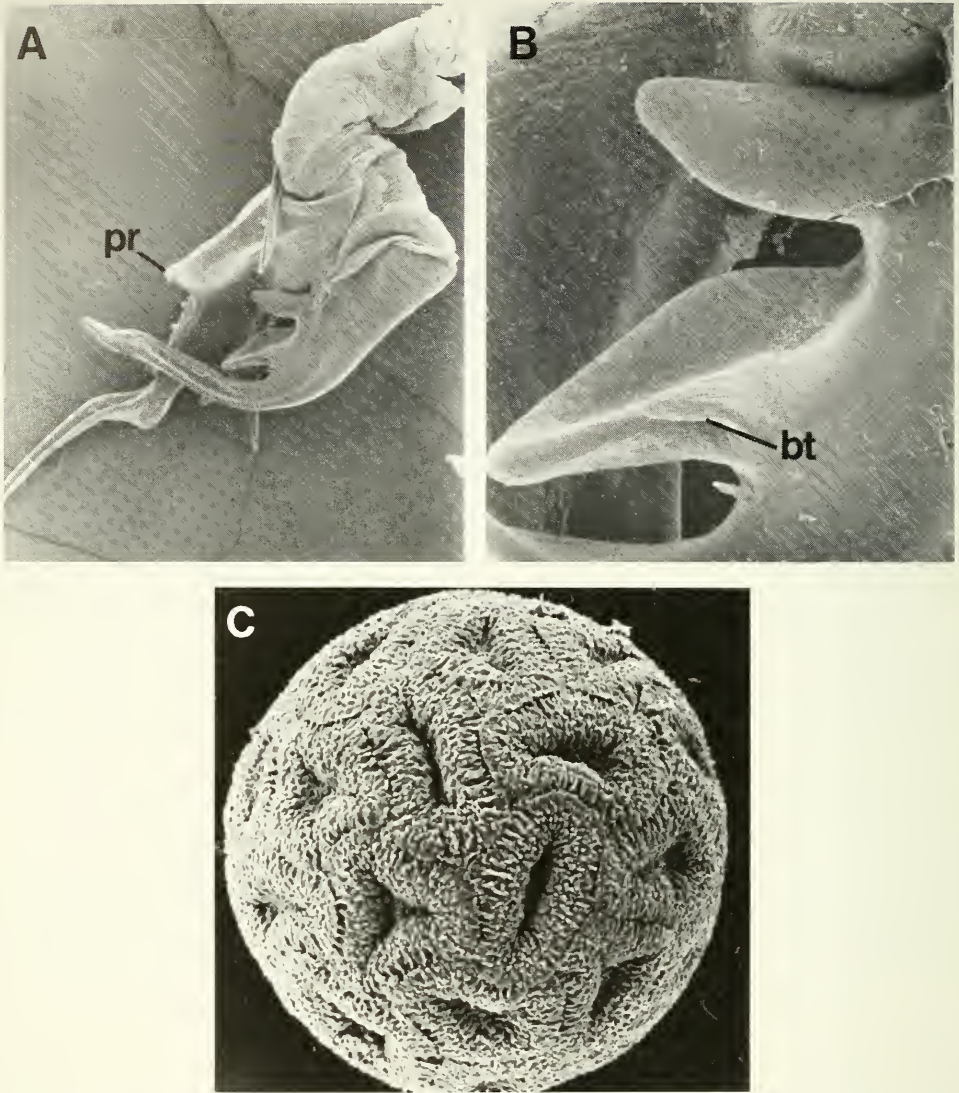


Fig. 2. *Streptocephalus bidentatus* sp. nov. A. Medial view of right antenna of male. $\times 31,5$. B. Medial view of detail of teeth on dorsal margin of finger. $\times 180$. C. Egg. $\times 315$. Abbreviations: bt = basal tooth, pr = projection.

Description of male

Antenna. Lateral process (lp) slender, curved, tapered and apically subacute (Fig. 1A). Median process of antenna (mp) of moderate length (ratio to body length 0,32 : 1). Proximal anterior region of thumb (th) with prominent projection (pr) on dorsal margin (Figs 1A, 2A). Distal region with distinct bend, long, slender and apically acute (Figs 1A, 2A). Angle between proximal and distal regions of anterior part of thumb approx. 125° . Slender spur (s) of moderate length, separated from anterior

part of thumb by two, occasionally three, rounded teeth of unequal size (Fig. 1A). Finger (f) about one-half length of thumb, dorsally curved, with apex slightly recurved and subacute. Dorsal margin of finger with digitiform proximal tooth, followed by larger, roughly triangular distal tooth with small, digitiform tooth basally (bt) on medial surface (Fig. 2A, B).

Frontal appendage moderate length, narrow, apically acute (Fig. 1B).

Cercopods. Long (ratio to body length 0.23 : 1) with outer margins convexly curved. Plumose setae along margins, replaced by strong, widely spaced spines on distal third of inner margin (Fig. 1C).

Egg morphology

Egg shell with isolated, lip-like units of variable size and shape, each consisting of an elongated central depression, surrounded by a broad, rounded rib with rugose patterning (Fig. 2C).

Differential diagnosis

The hand region of *S. bidentatus* closely resembles that of *S. macrourus* Daday and *S. vitreus* Brauer, particularly in the shape of the finger and thumb, and the two rounded teeth separating the anterior region of the thumb and the posterior thumb spur. In *S. macrourus*, however, the tooth on the dorsal margin of the finger is large and single, with a flattened appearance in lateral view and a small, basal digitiform tooth. *Streptocephalus vitreus* shares the presence of two teeth, the distal with a small basal tooth, with *S. bidentatus*, but the shape and size of these teeth distinguish the two species. Although there is intraspecific variation in the teeth on the dorsal margin of the finger of the *S. vitreus* specimens examined, the proximal tooth is always much lower and apically more rounded than in *S. bidentatus*. The distal tooth is also lower in *S. vitreus* and does not have a triangular shape. There is no variation in the shape and size of the teeth of the *S. bidentatus* specimens examined. In addition, the cercopods of *S. vitreus* have plumose setae along the entire inner margin and the distal region of the telsonic segment has a pair of pointed processes that are absent in *S. bidentatus*.

The presence of a third tooth between the anterior region of the thumb and spur is not a significant character. It occurs in some individuals in a population, as in both *S. macrourus* and *S. vitreus*.

Distribution

In addition to the localities already mentioned, *S. bidentatus* has also been collected from Mkuzi and Ndumu game reserves in north-eastern Natal and from Mala Mala Game Reserve in the eastern Transvaal. This species appears to be confined to the north-eastern region of South Africa and Swaziland, between 23° and 28°S and 32°30' and 31°20'E, but the northern limits of its distribution are uncertain.

Etymology

The specific name describes the two rounded teeth separating thumb and spur. This character is unique to the closely related *S. macrourus*–*S. vitreus*–*S. bidentatus* group of species.

Streptocephalus dendrophorus sp. nov.

Figs 3A-C, 4A, B

Type material

Holotype. SAM-A40827, 1 male (16,0 mm); collected from the vegetated peripheral regions of a rain-filled temporary pool on the Makatini Flats (27°24'S 32°10'E), by M. Hamer in October 1987.

Paratypes. SAM-A40828, 2 males, one with antennae and frontal appendage removed (17,0 and 16,0 mm); 1 male (6,2 mm), antennae not fully developed; collected from same locality as holotype.

Male

Antenna. Lateral process (lp) curved inwards, proximally broad, tapering to a narrow apex (Fig. 3A). Median process of antenna (mp) of moderate length (ratio to



Fig. 3. *Streptocephalus dendrophorus* sp. nov. A. Lateral view of frontal appendage and left antenna of male. B. Ventral view of basal processes. C. Dorsal view of male cercopods. Bar scale = 1 mm. Abbreviations: a = arm, bp = basal processes, f = finger, lp = lateral process, mp = median antennal process, pa = papillae, s = spur, th = thumb, tr = trunk, 1A = anterior branch, 1LV = latero-ventral branches.

body length 0.35:1). Pair of small processes (bp) with irregular inner margin, basal and ventral to median processes of antennae (Fig. 3B). Basal region of median process with 2–3 papillae (pa) on anterior margin (Fig. 3A, B), followed by 4–6 similar structures medianly at first bend. Anterior region of thumb (th) proximally folded (Fig. 4A), distal region slender, dorsally curved and apically pointed. Angle between proximal and distal region of anterior part of thumb approx. 170° (Fig. 3A). Angle between triangular spur (s) and anterior part of thumb approx. 90° . Finger (f) short (about one-half length of thumb), proximally broad and dorsally curved, with recurved acute apex (Figs 3A, 4A). Anterior margin of finger with long, convex, ridge-like tooth with anterior hook-like projection (Fig. 4A).

Frontal appendage. Long (ratio to body length 0.39 : 1) and complex. Trunk (tr) dividing into two lateral branches (1LV/LV) and a third anterior branch (1A) about a one-quarter way along total length. Branch 1A bifurcate with each arm (a) tapered and about one-third length of frontal appendage. Long digitiform processes at base of trunk, along proximal half of ventral margin of each LV branch and just proximal to the division of 1A. Apically two LV branches and two arms narrow and with papillate processes (Fig. 3A).

Cercopods. Moderate length (ratio to body length 0.21 : 1), straight, tapered and with plumose setae along both margins (Fig. 3C).

Egg morphology

Egg shell with large, simple, 4–6 sided fields, separated from neighbouring fields by thin, sharp ribs (Fig. 4B).

Differential diagnosis

Streptocephalus dendrophorus sp. nov. closely resembles the southern African *S. cladophorus* Barnard. The frontal appendage, cercopods and basal processes of the two

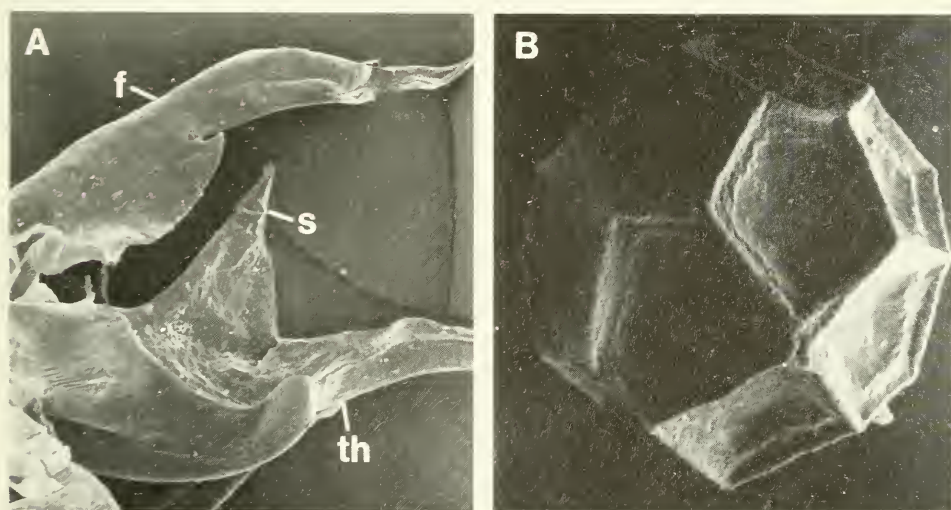


Fig. 4. *Streptocephalus dendrophorus* sp. nov. A. Medial view of hand region of male antenna. $\times 72$. B. Egg. $\times 315$. Abbreviations: f = finger, s = spur, th = thumb.

species are the same, and neither species has a tooth between the anterior region of the thumb and the spur. The most important differences between the two species, however, are in the hand region of the antenna. The angle between the anterior thumb and posterior spur is more acute and the spur narrower and more ventrally curved in *S. cladophorus*. Additional differences in the finger (long, slender and almost straight in *S. cladophorus*) and in the teeth on the anterior margin of the finger (a small rounded tooth or two unequally sized teeth in *S. cladophorus*) indicate two distinct species.

Distribution

Streptocephalus dendrophorus has, to date, only been collected from Mkuzi and Ndumu game reserves and the Makatini Flats in north-eastern Natal, between 26°50' and 27°35'S and 32°05' and 32°40'E.

Etymology

The specific name describes the elaborate, tree-like frontal appendage.

Streptocephalus spinicaudatus sp. nov.

Figs 5A–D, 6A–C

Type material

Holotype. SAM–A40829, 1 male (22.5 mm); collected at Umtata Dam, Transkei (31°30'S 28°36'E) by M. Schramm in September 1990.

Paratypes. SAM–A40830, 11 males (22.6 ± 1.1 mm), 3 females (21.5; 18.3; 21.3 mm), two with eggs in brood pouch, one with brood pouch damaged; collection data as for holotype.

Other material

SAM–A40831, 2 males (17.4, 17.3 mm) and 1 female (18.3 mm); collected at Sterkstroom (31°33'S 26°32'E) by J. Omer-Cooper in 1954.

Male

Antenna. Lateral process (lp) curved medianly, stout and apically subacute (Fig. 5A). Median antennal process (mp) of moderate length (ratio to body length 0.24 : 1), curved with 2–4 small papillae on medial surface distal to first bend. Thumb (th) with proximal fold produced to form prominent projection (pr) on anterior margin (Fig. 5A). Distal region of thumb with bend (Fig. 5A), after which thumb slender and apically acute (Figs 5A, 6A). Spur (s) moderate length, apically subacute, and separated from anterior region of thumb by large, triangular tooth (Fig. 5A). Angle between proximal and distal regions of anterior part of thumb approx. 130°. Finger (f) two-thirds length of thumb, dorsally curved with blunt, slightly indented apex. Anterior margin of finger with proximal digitiform, apically rounded tooth. Distal tooth larger and triangular (Fig. 6A, B).

Frontal appendage. Moderate length, apically rounded with small median indentation (Fig. 5B).

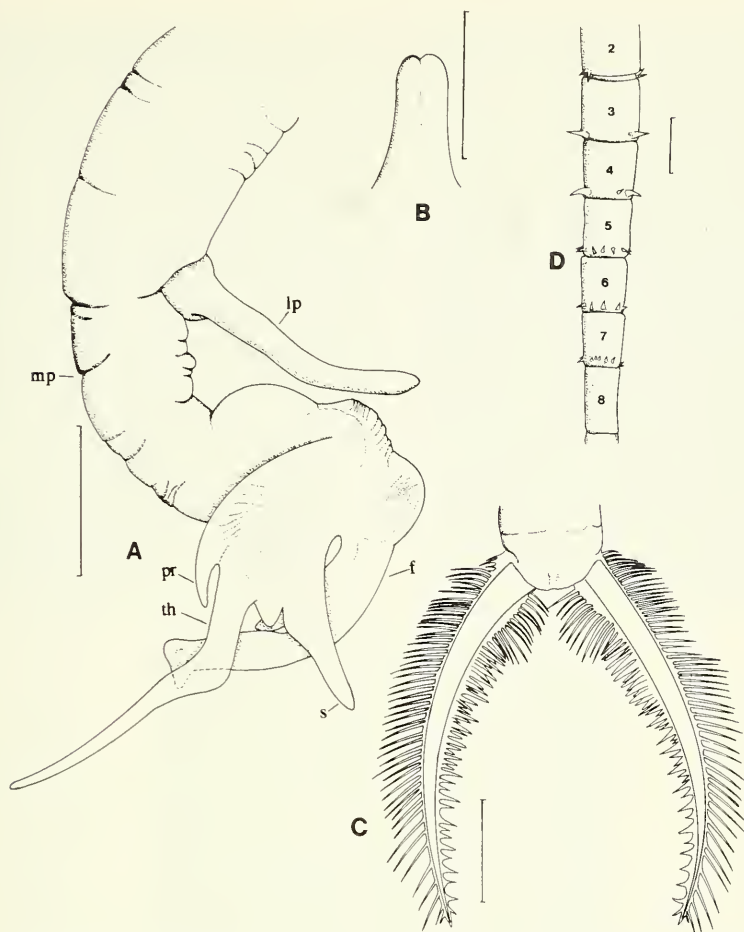


Fig. 5. *Streptocephalus spinicaudatus* sp. nov. A. Lateral view of left antenna of male. B. Dorsal view of frontal appendage. C. Dorsal view of male cercopods. D. Dorsal view of abdominal segments 2-8 showing spination. Bar scale = 1 mm. Abbreviations: f = finger, lp = lateral process, mp = median antennal process, pr = projection, s = spur, th = thumb.

Cercopods. Moderate length (ratio to body length 0.16 : 1), tapered with outer margins bent convexly. Plumose setae on outer margins, inner margins with patch of setae proximally, followed by stout, closely set spinous processes of unequal length. Distally these more widely spaced (Fig. 5C).

Abdomen. Posterior margins of abdominal segments 2-7 with spines. Segments 2-4 with lateral spines only, segment 5-7 with more numerous but smaller dorsolateral spines (Fig. 5D).

Egg morphology

Egg surface with folded appearance, irregular fields sunken with 4-5 sides, separated by rounded ribs of moderate width (Fig. 6C).

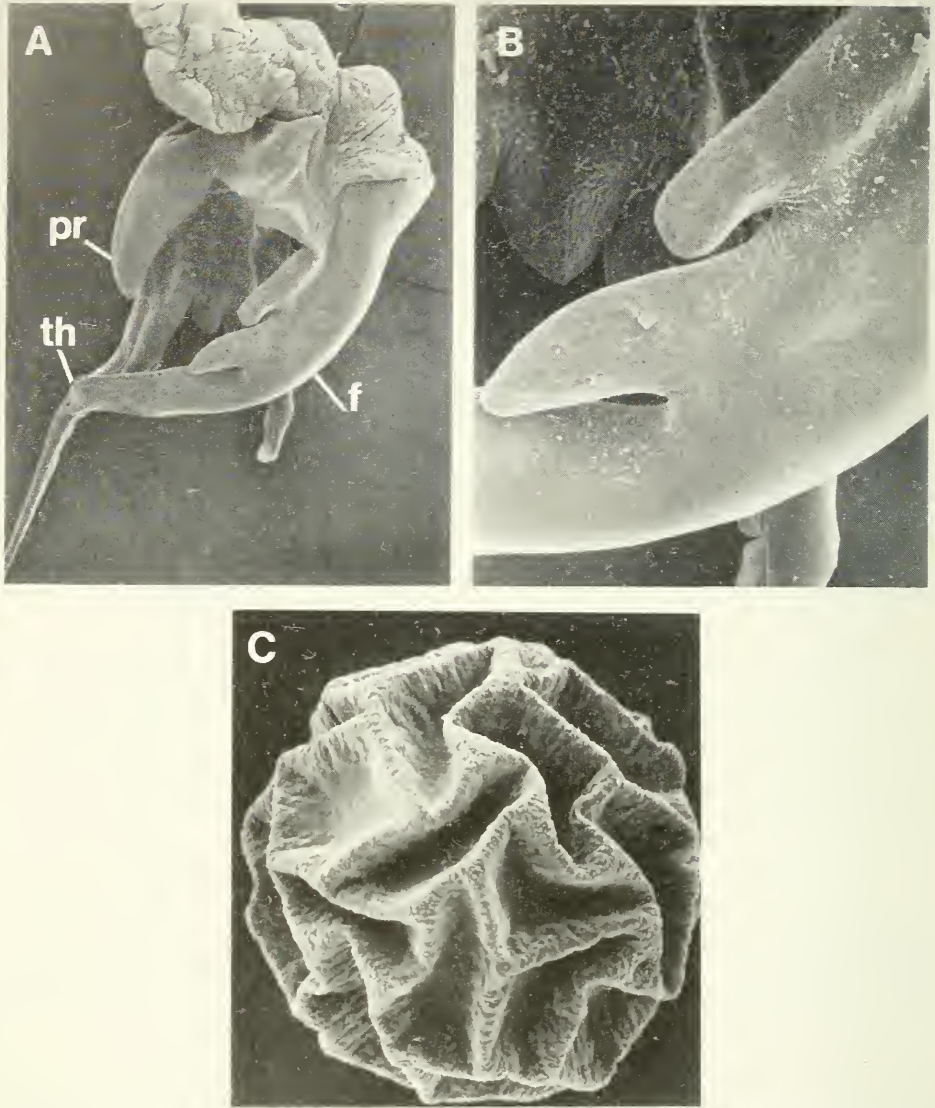


Fig. 6. *Streptocephalus spinicaudatus* sp. nov. A. Medial view of right antenna of male. $\times 31,5$. B. Medial view of detail of teeth on dorsal margin of finger. $\times 117$. C. Egg. $\times 315$. Abbreviations: f = finger, pr = projection, th = thumb.

Differential diagnosis

Streptocephalus spinicaudatus shares many morphological characters with the eastern Cape species *S. dregei* Sars. The latter species is, however, distinct from *S. spinicaudatus* in that it has a pair of basal processes ventral to the antennae, a large triangular tooth on the medial surface of the median process just proximal to the hand region, a single tooth on the anterior margin of the finger, slightly smaller abdominal spines, and more regular spinous processes on the inner margin of the cercopods. No

intraspecific variation has been observed in either the *S. dregei* or the *S. spinicaudatus* specimens examined.

Distribution

Streptocephalus spinicaudatus has only been collected from two localities in the eastern Cape and Transkei region of southern Africa.

Etymology

The specific name describes the spinous nature of the abdomen and inner margin of the cercopods.

Streptocephalus bourquinii sp. nov.

Figs 7A–D, 8

Type material

Holotype. SAM–A40832, 1 male (24.3 mm); left antenna and cercopods slightly damaged; collected in north-eastern Natal, Hluhluwe Game Reserve, Manzibomvu perennial stream (28°03'00"S 32°07'15"E), by Dr O. Bourquin, 28 April 1969.

Paratype. SAM–A40833, 1 female (25.5 mm), from the same locality.

Other material

BMNH 1963.10.1.1. 1 male (7.0 mm) and 1 female (7.5 mm); specimens collected from Tshaneni in Swaziland (26°01'S 31°46'E) in 1963.

Male

Antenna. Lateral process (lp) curved, apically blunt (Fig. 7A). Median antennal process (mp) of moderate length (ratio to body length 0.36 : 1), with 3–4 triangular processes (p) (Fig. 7A, B), followed by a larger irregular process (p2) just distal to first bend on anterior margin (Fig. 7B). Base of thumb (th) folded, with fold produced to form a prominent, narrow, pointed projection (pr) on anterior margin (Fig. 7A, B). Distal region of thumb bent dorsally and narrow, apically acute. Angle between proximal and distal parts of anterior region of thumb approx. 100°. Spur (s) short and tapered. Angle between spur and anterior region of thumb smooth and wide (approx. 130°) (Fig. 7A). Finger (f) about four-fifths length of thumb, tapered and with recurved and acute apex (Fig. 7A, B). Anterior margin of finger with large, roughly triangular tooth proximally, followed by long, ridge-like tooth (Fig. 7B).

Frontal process. Short, apically rounded with median indentation (Fig. 7C).

Cercopods. Moderate length (ratio to body length 1 : 0.16). Straight, tapered and with plumose setae along both margins (Fig. 7D). Setae short at apices, particularly in BMNH 1963.10.1.1 specimens.

Egg morphology

Simple, irregular polygonal fields with 4–5 sides, separated from neighbouring fields by broad, rounded, crenulate ribs (Fig. 8).

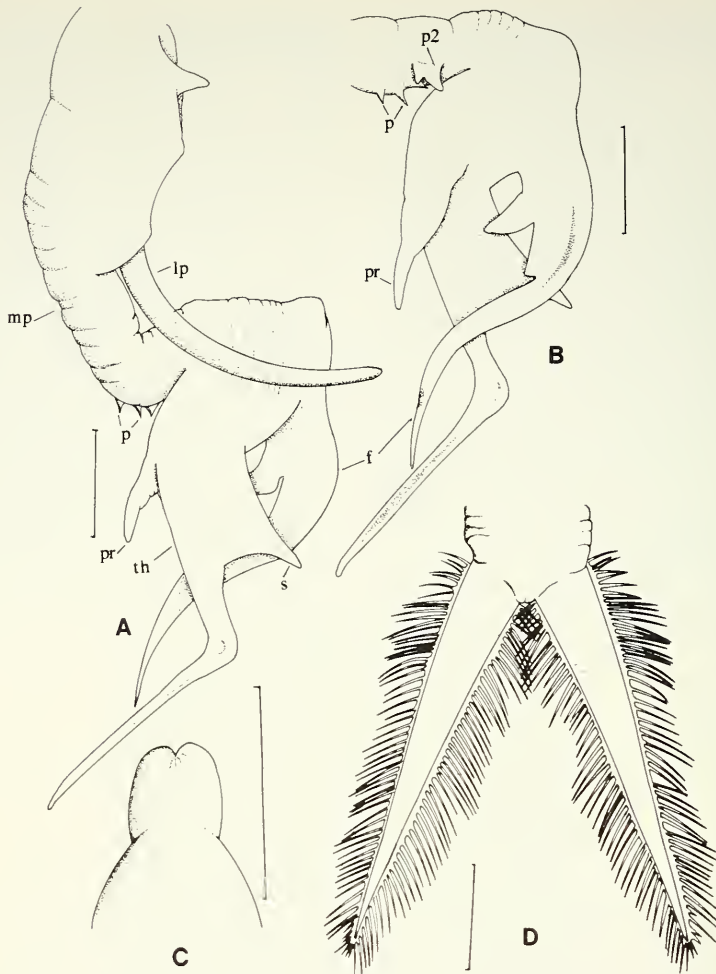


Fig. 7. *Streptocephalus bourquinii* sp. nov. A. Lateral view of left antenna of male. B. Medial view of hand region of antenna. C. Dorsal view of frontal appendage. D. Dorsal view of male cercopods. Bar scale 1 mm. Abbreviations: f = finger, lp = lateral process, mp = median antennal process, p2 = irregular process, p = triangular processes, pr = projection, pr = projection, s = spur, th = thumb.

Differential diagnosis

Streptocephalus bourquinii shares the following characteristics with the New World species *S. similis* Baird: a bilobed, rounded frontal appendage, the absence of a process between the anterior region of the thumb and spur, and the shape of the thumb and finger. The triangular and irregular processes on the median process are, however, absent in *S. similis*. *Streptocephalus bourquinii* has two teeth on the anterior margin of the finger, whereas *S. similis* has three, and these teeth differ in shape between the two species (see Moore 1958). *Streptocephalus bourquinii* also lacks the spines along the distal half of the inner margin of the cercopods of *S. similis*.

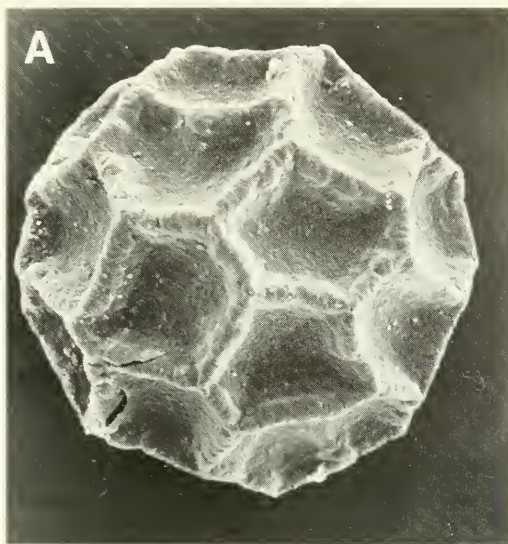


Fig. 8. *Streptocephalus bourquinii* sp. nov. Egg. $\times 315$.

Distribution

Streptocephalus bourquinii was also collected in 1986 and 1987 from Fannies Island (28°10'S 32°25'E) and False Bay Park (27°55'S 32°20'E) in the St Lucia area of north-eastern Natal, but these specimens were destroyed. The other localities of Swaziland and Hluhluwe indicate that this species is restricted to the north-eastern region of southern Africa.

Etymology

Streptocephalus bourquinii is named after Dr O. Bourquin of the Natal Parks Board, who collected the type specimens.

DISCUSSION

The seventeen southern African streptocephalid species can be divided into nine species groups based on similarities in antennal and frontal appendage morphology. Three of the four species described herein show a large degree of morphological similarity to known species. This allows for easy allocation to existing species groups. *Streptocephalus bidentatus* belongs to the same group as *S. macrourus* and the north and east African *S. vitreus*. The elaborate frontal appendage and antennal hand region of *S. dendrophorus* clearly place it with *S. cladophorus*. *Streptocephalus spinicaudatus*, because of its cercopod setation, abdominal processes and hand region, can be placed with *S. dregei* and *S. cirratus* Daday. *Streptocephalus bourquinii* does not show any distinct similarity to other African species. It can, however, be allocated to the rather broad species group that includes *S. cafer* Lovén, *S. indistinctus* Barnard, and the Madagascan species, *S. spinosus* Daday and *S. distinctus* Thiele, on the basis

of the shape of the thumb and finger and the projections on the median antennal process. If this species group is split, as it perhaps should be, into *S. cafer*–*S. indistinctus* and a separate group comprising *S. spinosus*–*S. distinctus*, *S. bourquinii* would not belong to either group. The latter closely resembles the New World species *S. similis*, but whether the similarity is a result of dispersal and subsequent speciation, or of parallel evolution, is debatable.

The presence of a number of species with very similar morphologies indicates that dispersal and/or successful colonization is not as common a phenomenon amongst the streptocephalids as would be expected in animals with drought-resistant, easily-transportable eggs. Gene flow between temporary pools was found by Fugate (1990) to be restricted in the American genus *Branchinecta*. Local adaptations resulting in speciation may thus be common in such habitats and this appears to have been the case in the African streptocephalids, as shown by the species described here.

The characters used to differentiate between species are probably related to specific mate recognition. Belk (1991) suggested that the female responds to tactile cues provided by the male antennae, frontal appendages and various forms of body armature during mate selection. The hand region of the antenna, in particular, appears to first reflect changes related to speciation in the African species examined. In the case of the species described here, the teeth on the anterior margin of the finger are the most striking indicators of speciation. Cercopod setation also seems to change early in relation to speciation and it is possible that this structure is also involved in mate selection. The frontal appendage, strangely enough, is a conservative character among those species described and appears to change at a slower rate than the antennae and cercopods. This is clearly shown by *S. dendrophorus* and *S. cladophorus*. Egg morphology does not always indicate separate species or relationships between species. For example, there is very little difference between the eggs of *S. bidentatus* and those of *S. vitreus* from the Sudan (Brendonck 1992), but the eggs of *S. spinicaudatus* are quite different from those of *S. dregei*. The large amount of intraspecific variation and overlap in egg morphology between species groups makes this an unreliable character in streptocephalid taxonomy.

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